WADC TECHNICAL REPORT 52-13

A REVIEW OF LITERATURE ON THE RELATIVE EFFICIENCY OF THE DOMINANT AND THE NONDOMINANT EYE

ALBERTA S. GILINSKY
COLUMBIA UNIVERSITY

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WRIGHT AIR DEVELOPMENT CENTER

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Alberta S. Gilinsky
Columbia University

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FOREWORD

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ABSTRACT

Evidence on the incidence of ocular dominance is summarized and the findings relevant to the comparative efficiency of the dominant and the non-dominant eye in various perceptual-motor skills and visual functions are reviewed. Although a small advantage for the dominant eye in cases of unmixed manual-ocular laterality is indicated by some studies, there is reason to doubt the permanence and universality of this superiority. No advantage for either eye is found in cases of mixed laterality for any function.

PUBLICATION REVIEW

Manuscript copy of this report has been reviewed and found satisfactory for publication.

FOR THE COMMANDING GENERAL:

Robert H. Blount

ROBERT H. BLOUNT
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Research Division

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INTRODUCTION

A review of the literature on ocular dominance with particular reference to tracking performance reveals few relevant studies. Research on ocular dominance has been largely concerned with the determination of the incidence of right and left-eyedness; the development of tests of dominance; and the question of the relation of eyedness to handedness and the general phenomenon of bilateral asymmetry.

Good general histories of the field may be found by McAndrews (1935) and Schoen and Schofield (1935). The present report will be largely confined to a review of the available evidence on the relative efficiency of the dominant and non-dominant eye in various functions. After a brief consideration of the limitations involved in the concept of eye dominance and its determination, the findings most pertinent to the problem of the importance of eye dominance in tracking behavior will be summarized. Although only one bit of research relating eye dominance directly to a tracking or pursuit skill can be found, some indirect evidence from target aiming and marksmanship studies is available. Investigations of eye dominance in relation to a variety of visual and perceptual functions will be brought together for whatever light they may throw on the general role of eyedness in perceptual-motor coordinations.

The Concept of Eye Dominance

The fact that animals and human beings tend to use the members of one side of the body rather than the other in the execution of movement appears to be well established. The laterality dominance of the hand, the foot, and the eye is widely recognized, although the particular side dominating may vary from one member to another, or from one activity to another with the same member. Thus an individual may show right dominance in respect of the arm and hand but left dominance in the use of legs or arms. Similarly he may write with his right hand but use the left hand for other tasks. The agreement between the dominant hand and the dominant eye, and also the agreement between acuity and eye dominance (the possession of superior acuity by the sighting or otherwise preferred eye) have been described as preferable to mixed laterality in these respects. These assumptions, brought into prominence by Parson's (1924) assertion that unilateral sighting or eyedness determines handedness, appear to underlie, or to have inspired most of the research in this field. The problem of the relation of mixed dominance to other forms of behavior has thus claimed the major attention of investigations, often with the implication that anomalies of central functioning were thereby revealed.

Although laterality of function is presumed to be related to cerebral dominance, the nature of this relation is by no means clear. In particular, the physiological mechanism or neurological basis of ocular dominance is not known. Since the functioning of either eye as a whole is dependent upon both cerebral hemispheres, the particular eye dominating cannot be an indication of the dominance of either hemisphere.

Investigation of the nature of ocular dominance, however, has been handicapped by the failure to devise generally acceptable criteria for classifying the types of dominance.

Critical examinations of the concept of 'eye-preference' or 'eye dominance' have repeatedly failed to establish a completely satisfactory operational definition. Crider (1944) analyzed the percents of right, left, and impartial eyedness collected by a number of different investigators. These percents varied considerably from one investigation to another, depending on the directions given, and the test used. See Table 1. Most importantly, according to Crider, on the basis of a large number of measurements, the percents depend upon the number of sightings permitted the examinee. As these are increased, the consistency of choice of one eye is diminished, and the proportion of ambiocular individuals increases. Whereas 93.3 percent of the subjects used one eye consistently in two trials, only 30.4 percent used the same eye throughout 45 different trials.

Most of the common tests devised to indicate eye dominance have been various kinds of sighting procedures. Usually these measure a preference for one eye over the other in situations where only one eye can be used. A variety of cone-shaped sighting devices, peep-hole sighting, and pointing methods are examples of such procedures.

Other widely used techniques of determining dominance are the convergence near-point method, the Irvine prism test (1950), the Jasper-Raney phi test (1937), binocular rivalry, and judgments of the relative chromaticity or brightness of the two ocular images. Detailed descriptions of these tests are given by Johnston (1942).

The lack of agreement between the different tests is markedly evident. In the first place, the agreement between "sighting" tests and other so-called "eyedness" tests is little better than chance. Thompson (1930) found that sighting tests yielded consistent results with convergence and chromatic tests for but 45 percent to 62 percent of the cases studied. Washburn, Faison, and Scott (1934) found that the preferred eye in sighting, using the Miles V-scope (1930), was the more responsive eye in retinal rivalry in only 33 percent of 57 cases. A number of other investigators, including Keller (1937), Johnston (1942) and Warren and Clark (1938), report as much or more disagreement between different tests.

Even relatively similar tests of eye dominance give differing preferences. The agreement between different "sighting" tests, while positive, is not high enough to insure that all are measuring a unitary factor. Using five different sighting tests in a study of 86 subjects, Thompson (1930) found that in no case was there perfect agreement between any two tests, the percent of agreement ranging from 60 to 81 percent.

Buxton and Crosland (1937) found that while the reliability quotient of each of four sighting tests was from .87 to .98, the intercorrelations varied from .44 to .71, only two being above .46. They conclude that "the existence of a unitary trait of eye preference is not established."

This conclusion is echoed by Warren and Clark (1938) after a review of the experimental and neurological evidence. These authors urge that the use of the term "ocular dominance" be accompanied by a statement of the specific method of measurement since the dominance is specific to the situation in which the measurement is made. These limitations upon the concept of eye dominance need to be kept in mind in considering the evidence presented below.

Distribution of Eye Dominance

Table I summarizes the results of different investigations on the relative frequencies of occurrence of right, left, and ambiocular dominance. Despite the variation in results, it is clear that ambiocular individuals constitute a minority, and that right-eyedness is more frequent than left-eyedness.

Corresponding percents for handedness have been reported, but findings relating handedness and sighting preferences are of more interest to the present review. The number of individuals whose hand preferences and sighting preferences coincide is difficult to assess in view of the widely varying definitions and estimates of both hand and eye dominance. However, for groups of normal subjects, the number of such unmixed cases has generally far exceeded the mixed cases. The following percents of coincident or unmixed dominance were found recorded in the literature or computed from the published data: 73.5 percent (Parson, 1924); 58.9 percent (Duff, 1931); 63.4 percent (Miles, 1930); 56.0 percent (Schonell, 1941); 75 percent (Dart, 1938); ca. 73 percent (Quinan, 1930).

TABLE I

Summary of Findings Showing Percents of Right, Left, and Ambiocular Dominance

Author	Subjects	Percent		
		Right-Eyed	Left-Eyed	Ambiocular
Bannister (1935	954 infantrymen	59.5	18.0	22.5
Bender (1942)	399 male college students	54.4	24.4	21.6
Coons and Mathias (1928)	112 high school students	68.9	12.4	18.7
Crider (1935)	717 subjects	54.0	25.0	21.0
Cuff (1928)	237 school childrer	72.9	21.1	6.0
Cuff (1931)	109 undergraduates	70.6	29.3	0.0
Fink (1938)	125 subjects	61.5	34.5	4.0
Fink (1938)	125 subjects	49.5	30.5	20.0
Gahagan (1933)	100 undergraduates	79.0	21.0	0.0
Hildreth (1945)	191 school children	56.2	36.6	6.8
Johnston (1942)	109 13 year-olds	51.4	36.7	11.9
Lund (1932)	526 subjects	69.8	25.5	4.6
Miles (1930)	203 adults	66.0	31.5	2.5
Miles (1929)	172 school children	67.0	30.0	3.0
Palmer (1947)	1,671 adults	54.7	36.6	9.7
Parson (1924)	877 school children	69.3	29.3	1.4
Quinan (1930)	2,331 university students	73.0	23.0	4.0
Snyder (1928)	410 students	64.0	21.0	15.0
Witty and Kopel (1936)	100 children	63.0	33.0	4.0

EXPERIMENTAL EVIDENCE

Eye-Hand Coordination and Dominance

Only one study bearing directly on the importance of eye dominance in a pursuit skill has apparently been reported. In 1935 Freeman and Chapman tested 40 college students, divided into a practiced and an unpracticed group, in a group pursuit task under each of four conditions of hand and eye dominance. Eye dominance was determined by the monoptometer (Lund, 1932) sighting test. The pursuit test required the tracing in ink upon cellophane of the movement of a dot as seen in a mirror below the writing surface. From the scores showing the percent of error (see Table II) the authors concluded that hand dominance plays a more important role in pursuit skills than does eye dominance. "The difference in favor of the dominant eye is only 0.04 percent when scores are averaged independent of the hand used. That both eye and hand dominance play a more important role in the early stages of learning a skill than in the later stages is indicated by a comparison of the scores of the practiced and unpracticed groups. This suggests that the phenomena of dominance may be obscured in many tests due to transfer, or cross education." No data on the statistical significance of the findings and no measures of variability are given in the original report.

Other studies of the dependence of eye-hand coordination upon eye dominance have employed a fixed rather than a moving target. As in the study cited above, the findings indicate that the difference between the dominant eye and the non-dominant eye as such is not important, but that agreement between the dominant hand and dominant eye leads to greater efficiency than does mixed or crossed laterality of hand and eye.

Lund (1932) investigated the effect of eye dominance upon eye-hand coordination. A target or aiming test required subjects to strike successive positions on a target fixed to the wall. Results (Table III) with 247 subjects showed that best scores were made with both eyes open, but that the dominant eye, as determined by the monoptometer, possessed a decided advantage over the non-dominant eye in the case of the unmixed groups, i.e., those in whom the dominant hand and eye agreed, the right-eyed dextrals and the left-eyed sinistrals. No advantage of the dominant eye is apparent in the case of the left-eyed dextrals, a mixed group. The superiority of the dominant eye found in the averages of the unmixed groups, however, did not always hold for individual cases. In fact, one in four was said to show a "margin of superiority for the non-dominant eye." For the left-eyed dextrals no difference was found between the non-dominant and the dominant eyes.

Similar results were obtained by Fink (1938) in a series of tests in which the degree of coordination of the two eyes and the two hands employed in various combinations was measured. Two coordination tests were used: a Target test which required the insertion of a pencil through

a 3 cm opening in a board placed at arm's length; and a Contact test in which a stylus had to be passed between and without touching two converging metal strips. Fink found that in 81 of the 125 cases tested the "use of the dominant hand and the dominant eye resulted in the highest degree of coordination. The combination with the next highest coordination was the dominant hand and the less dominant eye." No further quantitative data are given. In this study the dominant eye was ascertained by means of the Dolman sighting test for both near and far vision.

Studies relating eye dominance to marksmanship might be expected to reveal differential effectiveness of the two eyes inasmuch as rifle shooting from the right shoulder would seem to require unilateral sighting with the right eye. It is sometimes assumed that the dominant eye is an important factor affecting ability with the rifle, but the evidence suggests its importance has been exaggerated.

Simpson and Sommer (1942), in testing 190 freshman engineering students who practiced rifle shooting, found no correlation between the use of the preferred eye and marksmanship.

Other investigators report that ocular dominance does play a role in marksmanship, but not necessarily a large one. Lebensohn (1942) investigated the ocular dominance of 156 right-handed untrained recruits during marksmanship performance on a 200 yard course. He found only a small difference in shooting efficiency between the right and left-eyed in the upper quarter of each group, and recommends the use of both eyes during sighting.

Bannister (1935) compared the rifle classifications of each one of 954 British infantrymen (Marksman, 1st, 2nd or 3rd class shot, taken as a measure of shooting ability) with their eye dominance scores. The latter were grouped on the basis of three sighting tests as R (right eye), RC (between right and center), C (center), LC (between left and center), and L (left). The results (shown in Table IV) indicate that the dominant eye is slightly related to shooting ability, the man whose right eye is dominant having the advantage, when required to shoot from the right shoulder, over other men. Still, a fair percent of superior shots are contained within the L and L/C groups. Bannister accounts for the proportion of good shots among the left-eyed by special incentive conditions by which all rewards and promotions are based on rifle classification.

TABLE II

Error Scores in a Pursuit Skill Made by a Practiced Group (Group 1) and an Unpracticed Group (Group 2) under Four Conditions of Hand-Eye Combination.

Condition	Percent of Error		
	Group 1 (N = 20)	Group 2 (N = 20)	Combined Mean (N = 40)
Dom. hand with dom. eye	1.63	1.41	1.52
Dom. hand with non-dom. eye	1.60	1.51	1.55
Non-dom. hand with dom. eye	1.59	1.62	1.61
Non-dom. hand with non-dom. eye	1.64	1.72	1.68

(Data from Freeman and Chapman, 1935; Note that the lower the percent of error score, the more accurate the pursuit.)

TABLE III

Results of the Target or Aiming Test in Relation to Eyedness and Handedness.

Classification	Percent	Eye Used					
		Both		Dominant		Non-Dominant	
		Score	P.E.	Score	P.E.	Score	P.E.
Right-eyed Dextrals	69.1	55.1	1.9	61.2	2.2	67.1	2.4
Left-eyed Sinistrals	4.2	55.4	2.0	59.5	1.9	62.2	2.0
Right-eyed Sinistrals	0.8	56.2	--*	60.9	--*	63.1	--*
Left-eyed Dextrals	21.1	55.0	1.8	61.7	2.7	61.9	3.1
Binocular and Ambiguous	4.7	59.7	2.6				

* Data omitted in original report.

(Data from Lund, 1932, N = 247. Scores represent average errors in terms of mm deviations from the point aimed at in 10 successive thrusts; thus the lower the number, the better the score.)

TABLE IV

The Distribution of Eye Dominance Compared with the Rifle Classification of 954 British Soldiers.

Marksmanship Class	Dominant Eye					
	R	R/C	C	L/C	L	Total
Marksman and 1st Class	213	142	107	51	35	548
2nd and 3rd Class	95	118	108	55	30	406
Total	308	260	215	106	65	954
Percents						
Marksman and 1st Class	69.2	54.5	49.8	48.1	53.8	
2nd and 3rd Class	30.8	45.5	50.2	51.9	46.2	

(Data from Bannister, 1935.)

Visual Acuity and Dominance

Attacks upon the question of the superiority of the dominant or preferred sighting eye have been largely directed at the comparative visual acuities of the two eyes.

The assumption that the dominant eye is the eye with the greater visual acuity has sometimes been held. Thus, Woo and Pearson (1927) suggested that visual acuity be used as an index of eyedness, but most investigators have found no agreement between acuity measures and measures of ocular dominance.

Kuroda (1926) found no significant relation between eyedness and homolateral visual acuity.

In 1928 Snyder and Snyder declared that eye preference was not caused by the visual superiority of one eye. They found the preferred eye the weaker in many cases.

In the same year Cuff (1928) reports a lack of agreement between acuity and manuscopic tests of dominance.

Coons and Mathias (1928) also found that the better visual acuity at both 20 and 40 inces is not necessarily associated with the preferred eye.

Gahagan (1933) tested 100 undergraduates in an effort to determine the relation of unilateral dominance to visual acuity and concluded that dominance and acuity were independent visual phenomena. Of 33 cases with a superior acuity of the right eye, 26 showed right dominance, whereas of the 27 cases possessing greater acuity of the left eye, only 7 showed left eye dominance. In 27 cases the non-dominant eye was shown to possess greater acuity, and the remaining cases (40 percent) showed approximately equal visual acuity.

The conclusion that visual acuity is not related to dominance has also been attested by the work of Selzer (1933), Fink (1938), and Drenkhahn (1937).

An opposite conclusion comes from a more recent investigation in which Palmer et al (1947) found a significant difference between the visual acuities of the eyes in 1,246 cases of marked eye dominance. Only those cases in which the right or left eye were used exclusively in 12 trials with the Parson manuscopic test of dominance were included. In right eye dominance (776 cases) the right eye was found to be significantly better in acuity ($P < .01$). In left eye dominance (470 cases) a slight superiority ($P < .05$) of the left eye was found.

An explanation of the contradiction between these findings and those previously cited awaits further evidence. It has been suggested, however,

that discrepancies in this field inevitably result from the different methods of testing and criteria of dominance used by different investigators.

Another factor which might help to account for this particular disagreement is the age of the subjects tested. In a carefully controlled experiment on visual acuity, Geldard and Crockett (1930) showed that the difference between the eyes with respect to acuity is a function of age. They found wider variations in acuity differences at the upper age levels than at the lower. Some cases examined showed no differences at any age but such cases become less frequent with increasing age. General inefficiency of vision and large binocular differences occur concurrently. Absolute differences between the eyes are thus of significance only when considered in relation to absolute acuity. Now in the study by Palmer and associates, the population was unselected with respect to age, whereas other investigations have tended to restrict themselves to subjects of college age or younger. The use of a wider age range, then, together with the exclusion of cases who did not meet the unusually high criterion set for eye dominance may offer a possible basis for reconciling the apparently contradictory results.

Flicker Frequency and Dominance

Schoen and Wallace (1936) describe an experiment on 8 subjects in which the relative flicker frequencies were determined for the right and left eyes. No reliable differences between the dominant and non-dominant eyes appeared. This was believed to indicate that retinal events are unrelated to ocular asymmetry.

Similar results have been reported recently by Ireland (1950). For 24 subjects the differences betweeen the critical flicker frequencies obtained for dominant and non-dominant eye stimulation proved to be statistically insignificant in each of two testing sessions.

Eye Movements and Dominance

A variety of evidence indicates that the sighting eye does not necessarily direct or assume leadership in movements associated with convergence and divergence or stereoscopic vision.

Clark (1936) reported, on the basis of an eye-movement study of stereoscopic vision, that while one eye moved first from 75 percent to 88 percent of the time, there was no significant relation with the sighting eye as measured by the V-scope method (Miles, 1930). In a study of the time required to complete divergence movements during fixation in reading it was found that there was no significant difference in 60 percent of the cases. In 25 percent the sighting eye completed the movement first, and in 15 percent the movement was completed first by the non-dominant eye.

A separate investigation by Clark (1936) of convergence and accomodative convergence showed no significant differences between the behavior of the dominant and the non-dominant eyes. Evidence was also presented that due to eye-movement during stereoscopic vision, clear vision shifts from one eye to the other with no dominance manifested.

A relation has been suggested between muscular imbalance and the sighting eye. In a study of 143 pupils having muscle imbalance in one eye, Crider (1934) reported that they generally used the eye having the most efficient musculature in sighting with the manoptoscope and in Selzer's (1933) digit reading stereoscopic device.

Another study of 257 cases of muscle imbalance by Crider (1935) confirmed the belief that the eye with the muscle deficiency was "seldom the sighting or dominant eye."

In trying to answer the question of the relative "neuro-muscular efficiency" of the two eyes Schoen and Scofield (1935) measured the diplopia thresholds--the extent to which each eye can overcome prismatic stress before binocular single vision is disrupted, and also the time required for each eye to establish single binocular vision following its disruption--of 20 subjects. No significant difference in the diplopia threshold between the dominant and the non-dominant eye was found. A significantly (.01 level of confidence) greater duration of post-duction diplopia did appear, however, for the dominant eye. The differences, though slight, were interpreted as indicating greater neuro-muscular efficiency in the non-dominant eye.

Reading, Attention, and Dominance

Studies of ocular dominance in relation to more broadly perceptual functions such as reading, the range of attention, and apprehension fail to show greater proficiency for the dominant than for the non-dominant eye.

To test the effects of eye dominance upon "range of attention" scores, Anderson and Crosland (1933) exposed a horizontal row of letters in a tachistoscope for a 100 sigma interval to the dominant and the non-dominant eyes separately of each of 30 subjects. Although they found that the right-eyed subjects, throughout the experiment, were superior to the left-eyed in their reporting of the letters occupying the left-most positions of the field, the relative performance levels of the two groups were reversed in the case of the letters occupying the right-most positions.

A similar more recent experiment on the range of visual apprehension for stimuli falling in the right and left halves of the retinae of each eye was performed by Keller (1937) on 50 subjects. The results showed that ocular dominance, as measured by different tests (manoptoscope, paper-sighting, and convergence tests) had no effect on a) the range

of visual apprehension in either eye, and b) the relative amount of recall of letters on either side of the stimulus card. Unlike Anderson and Crosland, Keller reports that both the right and left-eyed subjects showed a slight tendency to recall more letters in the right visual field than in the left.

Research on reading disability has been undertaken on the assumption that mixed manual and ocular dominance is a causal factor. Dearborn (1931) claimed that clinical cases yielded a preponderance of such mixed cases, as well as more left-eyed and ambi-ocular, ambidextrous cases than appeared among normal readers. He further hypothesized that "left-eyed children are at a disadvantage in reading which requires a dextral sequence of movements." The bulk of the evidence fails to support either this hypothesis or the belief that mixed eye-hand dominance is associated with reading achievement. Studies by Witty and Kopel (1936), by Hildreth (1940) and by Johnston (1942) agree in finding that eyedness is unrelated to reading ability. Witty and Kopel (1936) present data indicating that mixed dominance (as well as consistent manual-ocular behavior) have no association with reading performance. On the basis of his thorough investigation of 109 thirteen year old public school children, Johnston (1942) concludes more cautiously that "there is no evidence to reject the hypothesis that any observed association between anomalies of lateral dominance and reading disability can be explained on the basis of chance fluctuations."

Finally, Coons and Mathias (1928) reported a study of reading in relation to eye dominance which is of particular interest to the question of the modifiability of eye dominance. Right-eyed subjects were made to read with the left eye, the right eye being occluded. After a period of this forced seeing, the subjects reported trouble in detecting an eye preference. Although no details are given, the authors conclude that dominance may be acquired by one eye through use, and at the same time the other eye loses in dominance through disuse.

Stability or Permanency of Eye Dominance

A search for further evidence on the question of the stability of ocular dominance or the extent to which it can be modified reveals few well established facts.

Most investigators subscribe to the opinion that once dominance for one eye is established, it can be reversed only with difficulty. Mills (1928) stated, apparently on the basis of observations on large numbers of cases, that "when the special paths of binocular control and monocular mastery are once established, they are not likely to be modified after adolescence by any disease or injury which still permits vision of approximately 6/20 in the affected eye."

Fink (1938) claimed that "while training, accident or disease may reverse the handedness of a person, the exclusive use of either the right or left visual line for sighting persists throughout life, severe ocular

disease or practical blindness being necessary to cause its reversal."

Miles (1930) and others report that successive tests show the same eye as dominant; indeed a test of dominance is deemed satisfactory only when it gives identical results upon re-administration. Miles observed in addition that special habits from training as with the microscope do not determine the eye dominance.

In a study of 190 children from three to six years of age, Updegraff (1932) found consistency in ocular dominance over a period of years in 75 percent of the cases. The frequencies of right and left-eyedness in these young children were shown to be similar to those reported for older children and adults.

On the other hand, several investigators, Coons and Mathias (1928), Cuff (1928), and Snyder (1928), present evidence that ambiocular tendencies increase with age. However, the range of ages studied under any given set of conditions has been too limited to permit more than the suggestion that age may be a variable worth further consideration.

Direct experimental evidence on the influence of training or practice on eye dominance is almost entirely lacking. Besides the finding of Coons and Mathias, (1928) cited above, that dominance can be changed by practice, only one other experiment appears to have been reported. This is an investigation of German soldiers by Hamburger (1943). A group of 221 subjects tested for eye dominance before and after training in binocular vision in range finding showed a loss of eye dominance after the training.

SUMMARY AND CONCLUSIONS

It appears that few generalizations can be extracted from the literature on ocular dominance with any degree of confidence. Either a valid and reliable method of determining ocular dominance has yet to be devised, or the concept of eye dominance itself refers to any one of a number of specific situations, and not to a unitary factor.

In view of the fact that different investigators have used different tests of dominance and that the intercorrelations between tests are very low, discrepant results are not surprising. On the basis of the meager evidence available the following conclusions must be regarded as highly tentative.

1. Studies relating eye dominance (as determined by sighting tests) to tasks of eye-hand coordination suggest that the combination of eye dominance and hand dominance is a considerably more important factor than eye dominance alone. Agreement between handedness and eyedness has been shown to lead to greater efficiency in pursuit and fixed target tests. Results showed no advantage for the dominant eye as compared with the non-dominant eye except in cases of unmixed laterality and in not all of these cases.

2. In general, eye dominance as determined by a variety of tests, has not been found to be significantly related to visual acuity. A contrary finding, based on a large number of cases of marked eye dominance, of a small but significant difference in favor of the dominant eye, calls attention to the selection of the population for study both with regard to age and to the degree of dominance.

3. In a variety of tasks requiring shooting or aiming at a target, the use of both eyes together has been recommended as superior to the exclusive use of either the dominant or the non-dominant eye.

4. No significant differences in the behavior of the dominant and the non-dominant eye are indicated for eye movements, flicker frequency, diplopia thresholds, range of apprehension, or reading achievement.

5. Evidence on the stability of eye dominance is inconclusive but there is some indication that an established dominance or its effects can be modified by training. The problem merits consideration for inclusion in a program of further research.

BIBLIOGRAPHY

Anderson, I. and Crosland, H. R. The Effects of Eye Dominance on "Range of Attention" Scores. University of Oregon Publications. Volume 4. 1933.

Bannister, H. A Study in Eye Dominance. British Journal of Psychology. Volume 26. 1935. pp. 32-48.

Bender, I. E., Imus, H. A., Rothney, J. W., Kemple, C., and England, M. R. Motivation and Visual Factors. Dartmouth College Publications, Hanover, New Hampshire. 1942.

Buxton, C. E. and Crosland, H. R. The Concept 'Eye-Preference.' American Journal of Psychology. Volume 49. 1937. pp. 458-461.

Clark, B. An Eye-Movement Study of Steroscopic Vision. American Journal of Psychology. Volume 48. 1936. pp. 82-97.

Clark, B. Photographic Measures of Accommodative Convergence. Transactions of the American Academy of Optometry. Volume 10. 1936. pp. 120-133.

Coons, J. C. and Mathias, R. J. Eye and Hand Preference Tendencies. Journal of Genetic Psychology. Volume 35. 1928. pp. 629-632.

Crider, B. The Relationship of Eye Muscle Balance to the Sighting Eye. Journal of Experimental Psychology. Volume 18. 1935. pp. 152-154.

Crider, B. A New Test of Eye Dominance. American Journal of Psychology. Volume 49. 1937. pp. 669-670.

Crider, B. A Battery of Tests for the Dominant Eye. Journal of General Psychology. Volume 31. 1944. pp. 179-190.

Cuff, N. B. The Interpretation of Handedness. Journal of Experimental Psychology. Volume 11. 1928. pp. 27-39.

Cuff, N. B. A Study of Eyedness and Handedness. Journal of Experimental Psychology. Volume 14. 1931. pp. 164-175.

Dart, C. Eye, Hand, and Foot Preferences of Mentally Subnormal Subjects Compared with Individuals of Normal and Superior Intelligence. Journal of Juvenile Research. Volume 22. 1938. pp. 119-122.

Dearborn, W. F. The Nature of Special Abilities and Disabilities. School and Society. Volume 31. 1930. pp. 632-636.

Dearborn, W. F. Ocular and Manual Dominance in Dyslexia. Psychological Bulletin. Volume 28. 1931. pp. 704.

Downey, J. E. Types of Dextrality and their Implications. American Journal of Psychology. Volume 38. 1927. pp. 317-367.

Downey, J. E. Laterality of Function. Psychological Bulletin. Volume 30. 1933. pp. 109-142.

Drenkhahn. Das Dominierende Auge. Deutsches Militararzt. Volume 2. 1937. pp. 212

Fink, H. W. The Dominant Eye. Its Clinical Significance. Archives of Ophthalmology. Volume 19. 1938. pp. 552-582.

Freeman, G. T. and Chapman, J. S. The Relative Importance of Eye and Hand Dominance in a Pursuit Skill. American Journal of Psychology. Volume 47. 1935. pp. 146-149.

Gahagan, T. Visual Dominance - Acuity Relationships. Journal General Psychology. Volume 9. 1933. pp. 455-459.

Geldard, F. A. and Crockett, W. B. The Binocular Acuity Relation as a Function of Age. Journal of Genetic Psychology. Volume 37. 1930. pp. 139-145.

Hamburger, F. A. Uber Monokulare Dominanz in Binokularen Sehakt. Klinische Monatsblätten Für die Augenheilkunde. Volume 109. 1943. pp. 1-11.

Hildreth, G. A School Survey of Eye-Hand Dominance. Journal of Applied Psychology. Volume 29. 1945. pp. 83-88.

Hildreth, G. The Development and Training of Hand Dominance IV. Developmental Problems Associated with Handedness. Journal of Genetic Psychology. Volume 76. 1950. pp. 39-100.

Ireland, F. H. A Comparison of Critical Flicker Frequencies under Conditions of Monocular and Binocular Stimulation. Journal of Experimental Psychology. Volume 40. 1950. pp. 282-286.

Irvine, S. R. A Simple Test for Binocular Fixation and Ocular Dominance. Air Surgeons Bulletin. Volume 1. 1944. pp. 6-7.

Jasper, H. H. and Raney, E. T. The Phi Test of Lateral Dominance. American Journal of Psychology. Volume 49. 1937. pp. 450-457.

Johnston, P. The Relation of Certain Anomalies of Vision and Lateral Dominance to Reading Disability. Monographs of the Society for Research in Child Development. Volume 7. 1942. Number 2.

Keller, M. Ocular Dominance and the Range of Apprehension. Journal of Experimental Psychology. Volume 21. 1937. pp. 545-553.

Lebensohn, J. E. Ocular Dominance and Marksmanship. Navy Medical Bulletin. Volume 40. 1942. pp. 590-594.

Lund, F. H. The Dependence of Eye-Hand Coordination upon Eye-Dominance. American Journal of Psychology. Volume 44. 1932. pp. 756-762.

McAndrews, L. Ocular Dominance. Archives of Ophthalmology. Volume 13. 1935. 449-455.

Miles, W. Ocular Dominance-Methods and Results. Psychological Bulletin. Volume 25. 1928. pp. 155-156.

Miles, W. Ocular Dominance Demonstrated by Unconscious Sighting. Journal of Experimental Psychology. Volume 12. 1929. pp. 113-126.

Miles, W. Ocular Dominance in Human Adults. Journal of General Psychology. Volume 3. 1930. pp. 412-429.

Mills, T. Eyedness and Handedness. American Journal of Ophthalmology. Volume 8. 1925. pp. 933-941.

Palmer, E. C., Seiser, M., and Lauer, A. R. The Relation between Ocular Dominance, Handedness, and Visual Acuity. Proceedings of the Iowa Academy of Science. Volume 54. 1947. pp. 263-265.

Parson, B. S. Left Handedness. New York. Macmillan Company. 1924.

Quiman, C. The Principal Sinistral Types. Archives of Neurology and Psychiatry. Volume 24. 1930. pp. 35-47.

Schoen, Z. J. and Scofield, C. F. A Study of the Relative Neuromuscular Efficiency of the Dominant and Non-Dominant Eye in Binocular Vision. Journal of General Psychology. Volume 12. 1935. pp. 156-181.

Schoen, Z. J. and Wallace, S. R. Ocular Dominance. Archives of Ophthalmology. Volume 15. 1936. pp. 890-897.

Schonell, F. J. The Relation of Reading Disability to Handedness and Certain Ocular Factors: II. British Journal of Educational Psychology. Volume 11. 1941. pp. 20-27.

Selzer, C. A. Lateral Dominance and Visual Fusion. Harvard Monographs in Education. Number 12. Cambridge, Mass. Harvard University Press. 1933.

Sheard, C. Unilateral Sighting and Ocular Dominance. American Journal of Physiological Optics. Volume 4. 1923. pp. 49-54; Volume 7. 1926. pp. 558-567.

Simpson, R. G. and Sommer, R. C. Certain Visual Functions as Related to Rifle Marksmanship. School and Society. Volume 55. 1942. pp. 677-679.

Snyder, A. M. and Snyder, M. A. Eye Preference Tendencies. Journal of Educational Psychology. Volume 19. 1928. pp. 431-433.

Updegraff, R. Ocular Dominance in Young Children. Journal of Experimental Psychology. Volume 15. 1932. pp. 758-766.

Warren, N. and Clark, B. A Consideration of the Use of the Term Ocular Dominance. Psychological Bulletin. Volume 35. 1938. pp. 298-304.

Washburn, M. F., Faison, C., and Scott, R. A Comparison Between the Miles A-B-C Test and Retinal Rivalry as Tests of Ocular Dominance. American Journal of Psychology. Volume 46. 1934. pp. 633-636.

Witty, P. A. and Kopel, D. Sinistral and Mixed Manual-Ocular Behavior in Reading Disability. Journal of Educational Psychology. Volume 27. 1936. pp. 132-134.

Woo, T. L. and Pearson, K. Dextrality and Sinistrality of Hand and Eye. Biometrika. Volume 19. 1927. pp. 165-199.